UNIVERSITY OF JOHANNESBURG

FACULTY OF SCIENCE

DEPARTMENT OF APPLIED CHEMISTRY
NATIONAL DIPLOMA: ANALYTICAL CHEMISTRY EXTENDED

MODULE CET1CY1
CHEMISTRY 1CY1 (THEORY)

CAMPUS **DFC**

NOVEMBER EXAMINATION

DATE: 13/11/2014 **SESSION: 08:30 –11:30**

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INTERNAL MODERATOR **DR N MAXAKATO**

DURATION 3 HOURS **MARKS 150**

NUMBER OF PAGES: 5 PAGES AND 1 ANNEXURE

INSTRUCTIONS: ANSWER ALL QUESTIONS
CALCULATORS ARE PERMITTED (ONLY ONE PER STUDENT).

REQUIREMENTS: ANSWER SCRIPTS.

INSTRUCTIONS TO CANDIDATES:

1. PLEASE ANSWER ALL THE QUESTIONS.
2. AVOGADRO'S NUMBER = $6{,}022 \times 10^{23}$

QUESTION 1

1.1 There are two binary compounds of mercury and oxygen. Heating either of them results in the decomposition of the compound, with oxygen gas escaping into the atmosphere while leaving a residue of pure mercury. Heating 0.6498 g of one of the compounds leaves a residue of 0.6018 g. Heating 0.4172 g of the other compound results in a mass loss of 0.016 g. Determine the empirical formula of each compound. (12)

1.2 Consider the following unbalanced equation:

$$\mathbf{Ca_3(PO_4)_2\,(s) + H_2SO_4(aq) \rightarrow CaSO_4(s) + H_3PO_4(aq)}$$

1.2.1 What mass of $CaSO_4$ is produced if 1.0 kg of $Ca_3(PO_4)_2$ and 2.0 kg of concentrated sulphuric acid solution (98% by mass) react ? (10)

1.2.2 Calculate the mass of excess reactant that remains after the reaction is completed. (4)

1.2.3 How many grams of $CaSO_4$ would you expect to obtain if the reaction had a 87.0% yield? (2)

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QUESTION 2

2.1 Describe the preparation of 500 mL of 0.500 M NH_3 solution starting with a 96,0% (m/m) NH_3 solution (density = 880 kg/m^3). (7)

2.2 10.0 mL of 0.020 M HCl is required to completely neutralize 5.00 mL of a 0.020 M strong base solution. Propose possible identities for the strong base. (6)

2.3 Determine the pH of a mixture of 50.0 mL of 0.100 M HCl and 100 mL of 0.200 M nitric acid. (7)

2.4 Identify the conjugate acid-base pairs in each of the following reactions:

2.4.1 $H_2O(l) + H_2CO_3(aq) \rightleftharpoons H_3O^+(aq) + HCO_3^-(aq)$

2.4.2 $C_5H_5NH^+(aq) + H_2O(l) \rightleftharpoons C_5H_5N(aq) + H_3O^+(aq)$ (4)

QUESTION 2 (CONTINUED)

2.5 0,1472 g of a metal sulphate solution, M_2SO_4 was treated with excess $BaCl_2$, resulting in the formation of a precipitate. The precipitate was filtered and dried and found to weigh 0.2327 g.

2.5.1 Write a net ionic equation for any reaction that occurs. (2)
2.5.2 Identify the precipitate and spectator ions. (3)
2.5.3 Identify the metal, M. (6)

2.6 Chromium has been investigated as a coating for steel cans. The thickness of the chromium film is determined by dissolving a sample of a can in acid and converting the resulting Cr^{3+} to $Cr_2O_7^{2-}$ with the sulphate ion:

$SO_4^{2-}(aq) + Cr^{3+}(aq) \rightarrow Cr_2O_7^{2-}(aq) + S_8O_4^{2-}(aq)$ (acidic medium)

2.6.1 Balance the above redox equation. (8)
2.6.2 In one analysis, a 40.0 cm^2 sample of a chromium-plated can was treated according to the above procedure. It took 8,58 mL of 0.0520 M K_2SO_4 to completely react with Cr^{3+}. Calculate thickness of the chromium film on the can. The density of chromium is 7.19 g/cm^3. (5)
[48]

QUESTION 3

3.1 State Le Chatelier's principle. (2)

3.2 Hydrogen for the use in ammonia production is produced by the reaction:

$CH_4(g) + H_2O(g) \rightleftharpoons H_2(g) + CO(g)$; endothermic

What will happen to the reaction at equilibrium if:

3.2.1 $H_2O(g)$ is removed. (2)
3.2.2 The reaction vessel is heated. (2)
3.2.3 An inert gas is added to the reaction container. (2)
3.2.4 CO(g) is added. (2)
3.2.5 The volume of the container is tripled. (2)

3.3 Consider the equilibrium:

$3Fe(s) + 4H_2O(g) \rightleftharpoons 2Sb(s) + 3H_2S(g)$

3.3.1 Is the above equilibrium a heterogeneous or a homogeneous equilibrium? Give a reason for your answer. (2)
3.3.2 Write the equilibrium constant expression for this reaction. (2)

QUESTION 3 (CONTINUED)

3.3.3 If the equilibrium constant = 2.0 x 10^{-14} for the above reaction, comment on the relative quantities of reactants and products in the above reaction and on the position of the equilibrium. (3)

3.4 At a particular temperature, 12.0 moles of SO_3 is placed into a 3.00 L rigid container, and the SO_3 dissociates by the reaction:

$$\mathbf{2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)}$$

At equilibrium 2.00 M of SO_2 is present. Calculate the value of K_C for the reaction. (7)

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QUESTION 4

4.1 Would you expect to find an element having both a very small first ionization energy and an electron affinity that also has a very large negative number? Explain. (6)

4.2 Consider the elements; **Br, Ne, K**

4.2.1 Arrange the elements in order of decreasing atomic radius. Explain your answer using the group and period trends of atomic radius. (2)

4.2.2 Explain how the group and period trends in atomic radius arise. (9)

4.2.3 Use your understanding of first, second and third ionization energies etc. and electron configurations to explain why the Si^{4+} ion exists but not Na^{4+}. (5)

4.3 Consider the elements with the following electron configurations:

$[Ne]3s^1$; $[Ne]3s^2$; $[Ne]3s^3$

4.3.1 Identify each of the above elements. (3)

4.3.2 Arrange these elements in order of decreasing first ionization energy. Explain your order. (2)

4.3.3 Explain the general periodic trend in first ionization energy. (4)

4.4 Write equations corresponding to the following:

4.4.1 the third ionization energy of Al. (1)

4.4.2 the electron affinity of O. (1)

QUESTION 4 (CONTINUED)

4.5 Indicate which of the following atoms in the pairs of atoms have the higher electronegativity.

4.5.1 F, O
4.5.2 Li, N (2)

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QUESTION 5

5.1 State the VSEPR theory and show how this system applies to molecules containing 2, 3 and 4 electron domains. (4)

5.2 Consider the polyatomic ion: NH_4^+

5.2.1 Sketch the Lewis structure for this ion. (2)
5.2.2 Use VSEPR theory to predict the shape of this ion. (2)
5.2.3 What electron domain geometry and bond angle do you associate with this ion? (2)

5.3 Explain why the bond angle of the CH_4 molecule is much higher than that of the NH_3 and H_2O even though they all have the same electron domain geometry. Use Lewis structures to explain your answer. (6)

5.4 The CO_2 molecule is polar because it contains two polar covalent bonds. Do you agree with this statement? Explain your answer. (2)

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QUESTION 6

6.1 Using an example explain how dipole-dipole forces arise in polar molecules. (2)

6.2 Study the Table below and answer the questions that follow:

Compound	**Boiling Point (^{0}C)**
HF	**19**
HI	**–35**
H_2O	**100**
H_2S	**10**

6.2.1 Explain why the boiling point of H_2O is so high. (3)
6.2.2 Why is the boiling point of HF lower than that of H_2O? (2)

QUESTION 6 (CONTINUED)

6.3 Consider the following three compounds:

HCl; CH_4; NaBr(aq)

Describe the types of intermolecular forces that you expect to see in each. Explain how you arrived at your answer. (3)

[10]